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Interactive comment on "Forest Fire Aerosol – Weather Feedbacks over Western North America Using a High-Resolution, Fully Coupled, Air-Quality Model" *by* Paul A. Makar et al.

Anonymous Referee #2

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The authors performed a detailed analysis of one-month long period of July 2019 over a part of the US and Canada. An online coupled model GEM-MACH was run with and without aerosol-clouds feedbacks and the difference in its performance was analyzed with attention paid to the regions and the episodes of vegetation fires. As a result of the analysis, the authors declare clear-cut advantages of the coupled meteorology-chemistry forecasts over non-coupled ones in case of non-trivial conditions, such as biomass burning events.

General comments

The discussion on advantages and disadvantages of online coupled models is inter-

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Discussion paper

esting and important. Being inevitable e.g. in climate- or some episode analysis, the online coupled systems have harder time in other applications, especially in routine operations, such as weather and air quality forecasting. They face the usual set of concerns: Are the resources needed for running such systems on a routine basis justified by the gain? Can these resources be invested in e.g. model resolution, domain size, comprehensiveness of dynamic and chemistry schemes, with better results? The current paper tries to answer some of these questions by applying the GEM-MACH coupled system in forecasting mode with related technicalities and constraints. In that sense, I found the paper undoubtedly interesting.

The general problem, however, was that the declared outcome of the analysis does not follow from the material. The authors state: “incorporating aerosol direct and indirect effect feedbacks can significantly improve the accuracy of weather and air quality forecasts”. I struggled to find ground for it.

The implementation of the forecasts has several compromises, which seem to have more than enough power to overshadow any effect of the system complexity. Arguably the most-significant problem is the strange decision to use a decade-old MACC reanalysis as the boundary conditions for the run. With all efforts, I could not understand it: the domain is comparatively small, boundaries are important and the Copernicus operational forecast is available from the same ECMWF source. It covers more species than the old MACC reanalysis, embeds quite detailed fire data, involves satellite data assimilation and has better resolution. One can also look at ICAP ensemble of global aerosol and atmospheric composition models: forecasts of some of them are available. The list can be extended. There is no shortage of real-time data and forecasts, many easily available, why not to use them? The extra effort is a blip compare to other arrangements.

A possible result of the inadequate boundary conditions was a very large bias of AOD – up to 0.25-0.3 in the Figure 14, which constitutes almost an order of magnitude. Comparing to that error, the effect of coupling is negligible. The problem is noted by the authors but with no follow-up. However, if the missing aerosols were indeed from the boundaries and consist of reactive and soluble particles of fire smoke or sea salt, the chemical, aerosol, and cloud processes of the simulations are completely jeopardized, and no conclusions can be drawn. This suspicion is supported by the low correlation coefficient for PM2.5 (< 0.3, Table 2), which also suggests serious deficiency in the aerosol content and processes.

A general expectation from incorporation of new important processes is that it must lead to a better system behavior, ability to follow the changes in the environment and, consequently, to better correlation with observations. Unfortunately, this crucial statistical parameter did not show any difference between the runs. An exception is the PM2.5 score in Western Canada where the no-feedback run won (table 2), which essentially disproves the paper conclusions. Improvements due to coupling were noticeable only for bias and statistics related to it. But with no effect on correlation, the same or even more significant effect could be achieved, apart from boundary conditions, by a trivial bias correction, either in the aerosol formation/removal schemes or even as post-processing.

A similar question arises from the fire plume coupling. Appreciating the idea and efforts, I could not miss the remark that the approach does not account for the heat released by the fires. Being usually a reasonable compromise between the complexity and gain, in this case it is hardly correct. The model takes a great deal of efforts to account for the aerosol impacts on energy budget but this add-on can easily appear smaller than the neglected impact of fires.

I also noticed seemingly unclear / contradicting sentences concerning the coupling: a statement in line 258 probably means that the P3 was used for the AIE whereas the explanation in line 243 says that P3 uses prescribed particles features rather than the data from the aerosol module. So, was the coupling so full as the paper repeatedly says?

Presentation of the material is heavy. The paper is monumental and wordy, in many places more resembling a textbook than a focused research manuscript. It pays off to a devoted reader but sometimes, this approach backfires. For instance, a long description of the simulations leaves out many important features of the setup and takes a great effort from a reader to grasp it. A summary table is needed here.

Summarizing, I found the paper heavy but interesting to read, presenting a good outline of the state of art and contributing to the discussion on added value of the online-coupled models. However, its conclusions do not follow from the presented material, which rather shows almost the opposite. As a result, a somewhat pushy bold style of the presentation does not look convincing and eventually annoys the reader.

I would suggest a major revision of the manuscript turning it into a discussion review paper. It should present the experiment in a neutral way and discuss its features, contributions from different system components to its overall skills, as well as the ways for making it better, both via the feedback mechanisms and via simpler steps of improving the models themselves and the setup of the simulations. In such a form, the extensive text will become an asset.

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